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The Quality of Heat-Insulating Masonry Mortar with Perlite

E S Gerasimova¹ and A D Il'yina¹

¹Ural Federal University, 19 Mira street, Yekaterinburg 620002, Russia

E-mail: e.s.gerasimova@urfu.ru

Abstract. A quality for any building material including the dry construction mixtures is very important. This is a complex concept that includes a set of properties that determines their suitability for intended use. So the heat-insulating masonry mortar should simultaneously have a low coefficient of thermal conductivity, sufficient strength, sufficient frost resistance, etc. And the material not always possesses the characteristics that the manufacturer claims. In this regard it is of interest to conduct tests of finished products for their compliance both Russian Standard and presented characteristics. This work is devoted to main properties determination of heat-insulating masonry mortar produced by JSC “Quick-mix”.

1. Introduction

The term “mortar” combines the concepts of “mortar mix”, “dry mortar mix” and “mortar”. Construction mortar is a material obtained by solidification of a mixture of binder, fine aggregate, water and special additives. Before solidification this mixture is called a mortar mix. Dry mortar mix is a mixture of dry components: binder, aggregate and additives which are batched and mixed as a rule in the factory and mixed with the water before use. The binder in the mortar envelops the aggregate grains reducing friction between them, as a result of which the mortar mixture acquires the necessary mobility to work with it, and in the process of hardening the binder firmly binds the individual particles of the aggregate and the filler. Cement, clay, gypsum, lime or their mixtures are used as a binder, and sand of different origin is used as an aggregate [1-3].

According to Russian Standard 28013-98 mortar can be classified by the main purpose: it is possible to distinguish separate group of masonry mortars. Masonry mortar is used in the construction of masonry of bricks, concrete and stone blocks [4].

In accordance with modern standards of update construction, both wall materials and masonry mortars are subject to increasingly high requirements for heat and energy saving. Therefore, to meet these requirements it is necessary to create innovative mortars that optimally suites to wall materials with high thermal insulation properties [5]. Such thermal insulation mortars are necessary for energy-saving construction, as they can significantly reduce the amount of energy required for heating the buildings. Due to the optimal combination of special light mineral aggregates in the warm mortars composition along with improved mobility and ease of processing, high strength and durability of the masonry is achieved especially in the construction of masonry from porous brick (blocks) and similar materials.

Thermal insulation masonry mortar is a mixture of cement or cement-lime binder with special mineral inclusions that improve its insulating properties. Most often it is a perlite or keramzit (expanded clay aggregates). There are also thermal insulation masonry mortars with expanded polystyrene granules. Due to the introduction of these materials the mortars have a reduced density,



reduced thermal conductivity which varies from 0.18 to 0.24 W/m·deg (depending on the brand and manufacturer) which is almost 4 times less than that of ordinary cement mortar (its $\lambda = 0.90$ W/m·deg) [1-2].

The use of a warm mortar for enclosing structures eliminates heat losses through the mortar seams and improves the thermal properties of the masonry by 10-15 % with a seam thickness of about 12 mm while the usual mortar due to the insufficient coefficient of heat transfer creates a cold bridges in the masonry reducing the thermal insulation properties of the wall.

At the moment in the market of construction materials there are many manufacturers of dry mixes, including warm masonry mortars. Table 1 presents a comparative description of these mixtures of the main manufacturers. They are the most popular and common [6].

Table 1. Comparative table of main warm masonry mortars.

Trade mark	The mass of the bag (kg)	λ (W/m·°C)	Bulk density (kg/m ³)	Strength (MPa)
Quick-mix	17	0.190	540	5
Knauf	20	0.240	800–1000	5
Terta	25	0.270	1000	8
Kreisel	20	0.166	640	4
Murexin	20	0.190	650	5

A quality for any building material including the mixtures mentioned above is very important. This is a complex concept that includes a set of properties that determines their suitability for intended use. So the heat-insulating masonry mortar should simultaneously have a low coefficient of thermal conductivity, sufficient strength, frost resistance, etc. And the material not always possesses the characteristics that the manufacturer claims. In this regard it is of interest to conduct tests of finished products for their compliance both Russian Standard and presented characteristics.

2. Results and discussion

The material under study is a heat-insulating masonry mortar designed for laying of wall materials with high thermal insulation properties as well as used to fill cracks and voids. As a heat-insulating filler in its composition perlite is used – crushed rock of volcanic origin mainly consisting of SiO₂. Table 2 presents the technical characteristics of the material according to the manufacturer [7].

Table 2. Technical properties of mortar at + 20 °C relative humidity 60 %.

Mix grade	M50 (according to Russian Standard 31357-2007)
Density of set mortar	≤ 700 (kg/m ³)
Thermal conductivity	$\leq 0,18$ (W/m·deg)
Compressive strength	≥ 5 (MPa)
Aggregate particles size	0–4 (mm)
Application temperature	up +5 °C to +30 °C
Usage time	~ 2 hours
Mobility grade	Pk2
Frost resistance	F50
Water quantity	~ 10–11 liters per 17,5 kg
Mortar yield	~ 25–27 liters from 17,5 kg of dry mix

In accordance with Russian Standards for dry mixes the properties of the initial dry mix, mortar mixture with water and solidified mortar are determined. For the dry mix humidity and particle size

distribution are controlled which was determined using a standard set of sieves according to Russian Standards 8735-88. The result of determining the grain composition of the mix is shown in table 3. Figure 1 shows the dispersion curve from the test results. It was found that the grain content of a certain dispersion is within acceptable limits.

Table 3. Grain composition of the dry mix.

Residue	Residues (% by mass) on sieves						Passage through a sieve with mesh N 0.16 (% by mass)
	5.0	2.5	1.25	0.63	0.315	0.16	
Partial	0.05	5.16	4.24	4.90	52.36	26.34	7.05
Full	0.05	5.21	9.45	14.35	66.70	92.95	100.00

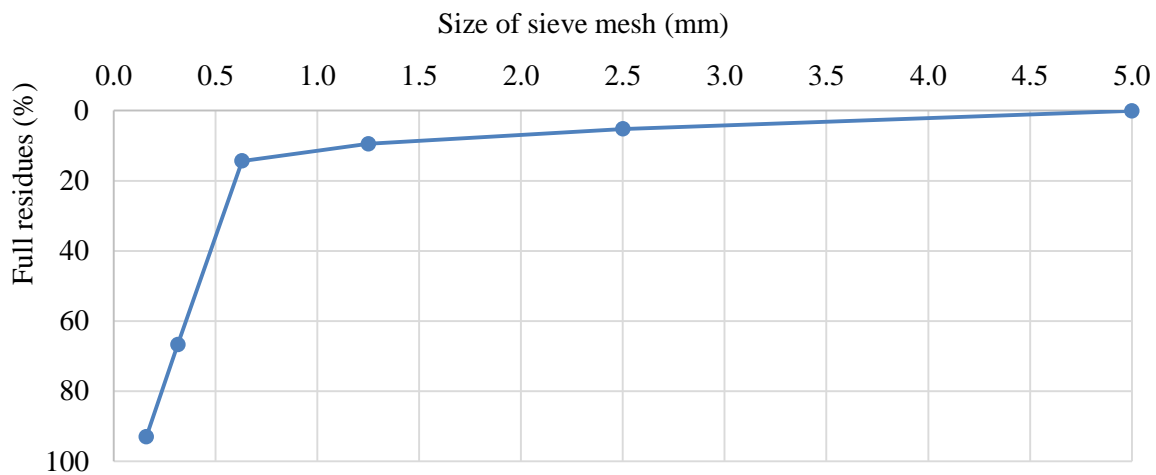


Figure 1. The curve of size dispersion of the dry mix.

The bulk density is 535 kg/m^3 therefore the mix is lightweight. The humidity of the tested dry mix was $\Delta W = 0 \%$ which corresponds to the requirements of Russian Standards [8-9].

According to the technical data 10-11 liters of mixing water per 17.5 kg of dry mix is required for the selected warm masonry mortar [7]. For the tests a sample equal to 2 kg was taken. Taking into account the recommendations of the manufacturer a water-solid ratio is 0.6. Eventually the volume of the solution mix was increased, its change was $\Delta V = 5 \%$.

An image of a fresh mortar mixture is shown in figure 2, on the left. As one can see the resulting consistency of the mix does not meet the requirements for masonry mortars: the mixture was rigid, consisting of separate pieces so it was decided to increase the water-solid ratio up to 0.85. The resulting consistency is shown in figure 2, on the right: with increased water-solid ratio the mix is similar to a homogeneous paste without signs of water separation and stratification.

Further the main characteristics of the finished mortar mixture were determined, the results are shown in table 4.

In accordance with Russian Standards 31357-2007 the persistence of the initial mobility of mixtures ready for use is determined by the time of preservation of the initial mobility in minutes [8]. The retention of the initial mobility of the mix shall not be less than the time during which the mixture is produced at the construction or repair site.

According to the technical documentation the time of tested mixture use is 2 hours which means that the mixture must retain its original mobility for 2 hours. To test this indicator an experiment was carried out to measure the mobility of the mix from the moment of its preparation every 15 minutes for

3 hours. The experiment was conducted on a single sample to completely bring the experimental conditions to the real: at the place of use the mixture prepared for using is in the container all the time until it is completely developed. The results of the determination of the mix mobility are shown in figure 3 [10-11].

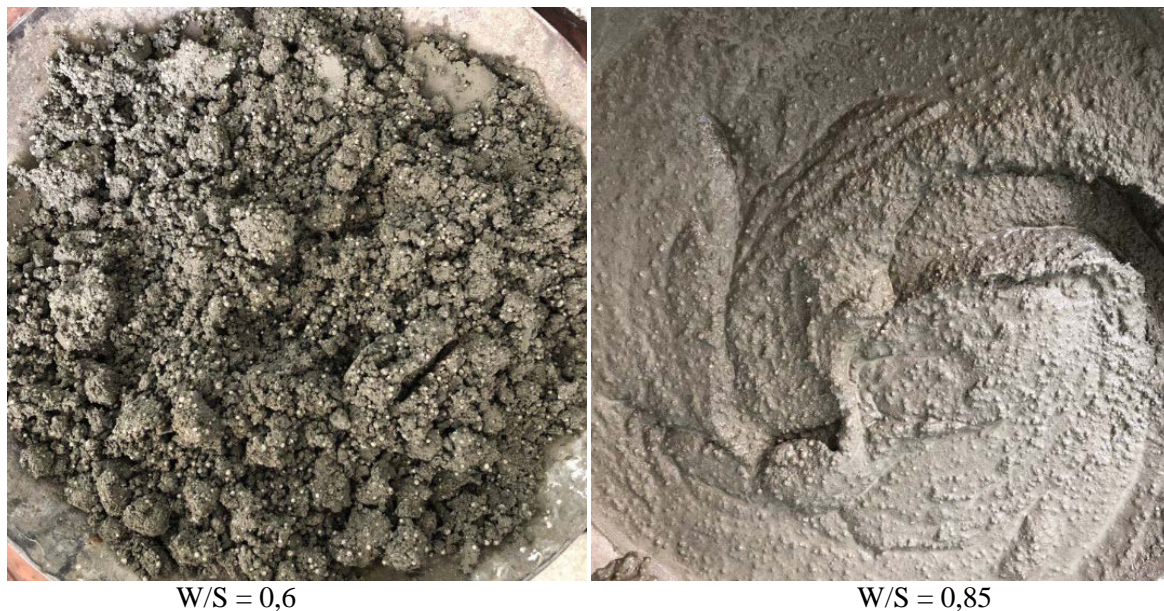


Figure 2. General view of the mixture at different water-solid ratio.

Table 4. Properties of mortar mix.

Property	Value
The density of the prepared mortar mix (kg/m ³)	1030
Water-holding capacity (%)	98.8
Mobility of mortar mix (cm)	10.7

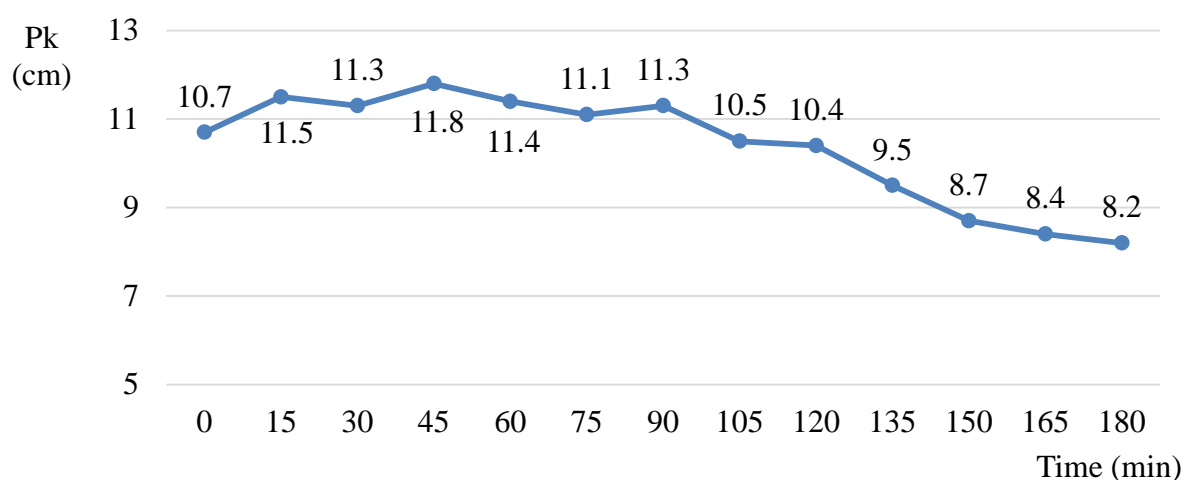


Figure 3. Results of mix mobility keeping measurement.

After conducting all tests with a freshly prepared mixture standard specimens-beams (4x4x16 cm) were molded [10-11]. At the same time it was interesting to study how the holding time of the mix

before molding affects the strength of the hardened mortar. For this purpose three batches of samples were formed: the first batch was formed 10 minutes after mixing and preparation of the mix, the second – after 1 hour and the third – after 3 hours. This time was also chosen on the basis of data close to the real conditions of use of such a mixes. The results of measurements of compressive strength of all batches of the mortar are shown in figure 4.

It was found that long-term exposure has no negative effect on the strength index and even when forming samples after an hour the strength of the mortar is greater than the strength of the batch molded immediately after preparation of the mix. This may be due to a violation of the original structure of the cement binder formed and recrystallization of crystallohydrates that are part of Portland cement.

The density of the solidified mortar was equal to 977 kg/m^3 which is 39 % higher than the declared manufacturer. The coefficient of thermal conductivity was equal to 0.2 W/m deg which is 11 % higher than stated.

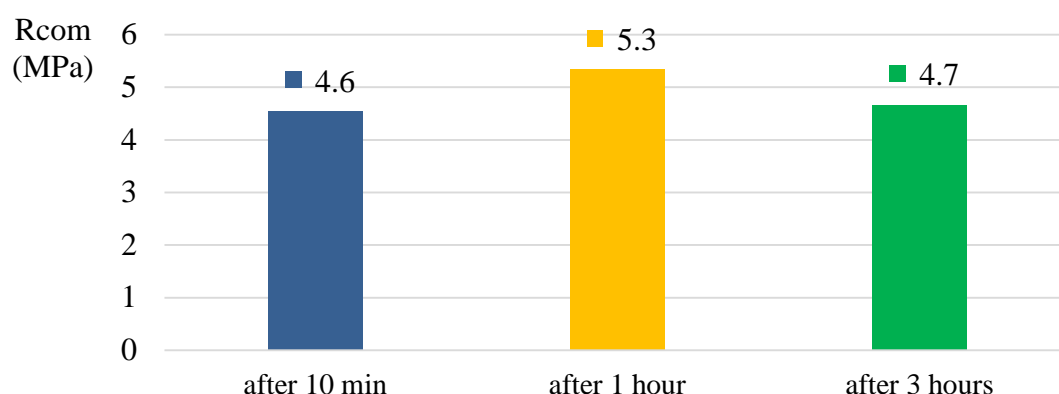


Figure 4. Compressive strength of the mortar depending on the holding time of the mix up to the samples molding.

3. Conclusion

The main characteristics of the dry building mix, freshly prepared mix and solidified mortar in accordance with the requirements of Russian Standards were determined (table 5). The size of the aggregate and humidity correspond to the manufacturer's data and the requirements of Russian Standards.

Table 5. Results of mix testing.

Indicator	Actual value	Manufacturer details	Russian Standards 28013–98
Water-solid ratio	0.85	0.6	–
The size of aggregate (mm)	0-5	0-4	–
Humidity (%)	0	-	corresponds
Water-holding capacity (%)	98.8	-	corresponds
Mobility grade (cm)	Pk 3	Pk2	corresponds
Using time (hours)	2	2	–
Density of set mortar (kg/m^3)	977	≤ 700	–
Coefficient of thermal conductivity ($\text{W}/(\text{m}\cdot^\circ)$)	0.20	≤ 0.18	–
Strength grade	M25	M50	corresponds

The water-solid ratio does not correspond to the manufacturer's data. The tested mixture according to Russian Standards 28013-98 has a brand of mobility Pk3 whereas according to the manufacturer –

Pk2. To create the necessary consistency the amount of mixing water was increased by 42 %. Water-holding capacity of the mortar corresponds to Russian Standards 28013-98. The mortar mixture retains mobility for 2 hours which corresponds to the manufacturer. The average density of the solution in the solidified state is higher than indicated by the manufacturer. The solution in accordance with Russian Standards 28013-98 is the brand for the compressive strength of M25 which is not consistent with the data of the manufacturer [4, 8-9].

References

- [1] Bazhenov Yu M, V F Korovyakov and Denisov G A 2003 Technology of dry building mixes, (Moscow: Publishing house ASV)
- [2] Kozlov V V 2000 Dry building mixes, (Moscow: Publishing house ASV)
- [3] Jornet A, Mosca C, Cavallo G and Corredig G. 2012 Comparison Between Traditional, Lime Based, and Industrial, Dry Mortars. In: Válek J., Hughes J., Groot C. (eds) Historic Mortars. RILEM Bookseries (Springer, Dordrecht. vol 7)
- [4] Russian Standard 28013–98: Construction mortars. Technical conditions. Russian Standard Institution, Moscow
- [5] Miletic M 2014 Use of Transparent Insulation Materials as One of the Measures of Improving Energy of Structures. In: Dincer I., Midilli A., Kucuk H. (eds) Progress in Exergy, Energy, and the Environment (Springer, Cham)
- [6] Khomich V A and Emralieva S A 2010 Dry construction mix. *Concrete and reinforced concrete* **2** 18-20
- [7] 2019 Official site of Quick-mix. URL: <http://katalog.quickmix.ru/lm-21-p-teplyj-kladochnyj-rastvor-s-perlitom> (Date 25.05.2019, Electronic Materials)
- [8] Russian Standard 31357–2007: Dry building mixtures based on cement binder. Technical conditions. Russian Standard Institution, Moscow
- [9] Russian Standard P 57337–2016/EN 998–2:2010: Construction masonry mortars. Technical conditions. Russian Standard Institution, Moscow
- [10] Russian Standard 31356–2007: Dry building mixtures based on cement binder. Test methods. Russian Standard Institution, Moscow
- [11] Russian Standard 5802–86: Construction mortars. Test methods. Russian Standard Institution, Moscow